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Studies on Variability of Indigenous Mulberry Germplasm on Growth and Leaf Yield

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ABSTRACT

Twenty-five indigenous mulberry germplasm were evaluated for growth and yield traits in a partial balanced lattice design at Central Sericultural Germplasm Resources Centre, Hosur, Tamil Nadu, India. The leaf yield performance showed high variation among the mulberry accessions. Analysis of variance on growth and yield showed significant variation among the accessions for all the traits. Seasonal variation was also observed in respect of leaf yield. The interaction between accession and season was highly significant for all traits. The coefficient of variation was maximum for single leaf weight (36.32%) and minimum for leaf moisture content (2.08%). The correlation coefficient analysis indicated significant association of leaf yield and other growth traits. The number of branches per plant, length of the longest shoot, total shoots length, leaf moisture content and leaf moisture retention capacity showed associations at different levels of significance with leaf yield. Other traits showed complex relationships with each other. Divergence analysis grouped 25 indigenous mulberry accessions into 7 clusters. Maximum accessions were grouped in cluster I (6 acc.) followed by cluster II (5 acc.) V (5 acc.), VII (4 acc.), IV (3 acc.) and minimum one each in cluster III and VI. The diversity among the accessions measured by inter-cluster distance (D2) showed variation. The cluster group indicates that mulberry accessions were distributed in different clusters irrespective of geographical distribution. The CIMMYT selection index shows that mulberry accession MI-0416 performed better among the accessions studied followed by MI-0308, MI-0376, MI-0437 and MI-0310. Other accessions showed higher index value that is less suitable for selection.

Keywords: Mulberry germplasm, variability, indigenous, growth, leaf yield

INTRODUCTION

Mulberry, a heterozygous perennial plant is the principal food of silkworm (*Bombyx mori* L.). The mulberry germplasm provides suitable material for silkworm feeding and hence the importance lies in maintaining a large number of germplasm to develop improved elite genotypes. Due to the needs of the sericulture industry, improved mulberry varieties are being developed and maintained. The improvement in quantity and quality of mulberry genotypes over the existing ones is a continuous process and breeders want suitable parental material for developing superior genotypes. Moreover, at present, there is increasing demand to develop region and season specific mulberry varieties to feed silkworm races. The central Sericultural Germplasm Centre is maintaining 1100 mulberry germplasm collected from 26 different countries. The mulberry accessions are continuously being characterized and documented. Many of the mulberry accessions have been characterized for morphological as well as important economic traits (Thangavelu *et al.*, 2000). Knowledge of genetic variability is important for breeding (Frankel and Brown 1983; Frey *et al.*, 1983) and useful to improve the specific set of characters in low yielding mulberry germplasm. The diversity, variability and related factors have been highlighted by different authors on growth and yield traits (Fotedar and Dandin, 1998; Tikader *et al.*, 1999; Tikader and Rao, 2002, Tikader *et al.*, 2003; Vijayan *et al.*, 1999). Various authors reported the association of leaf yield with other

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traits in mulberry (Vijayan *et al.,* 1997). Thereafter the selected elite germplasm is needed for testing using appropriate statistical designs to know the actual performance for further assessment. At present, information on germplasm evaluation under field conditions is scanty.

The present study was initiated to identify suitable mulberry accessions based on variability, association and performance over seasons to select suitable genetic materials for further utilization.

MATERIALS AND METHODS

Plant Materials

Twenty-five indigenous mulberry accessions were used in this study. The collections of mulberry accessions were from different states in India as follows: Uttarakhand (8), Karnataka (6), Kerala (5), West Bengal (2) and 1 each from Uttar Pradesh, Assam, Meghalaya and Tamil Nadu (Table I).

Experimental Layout

The experiment was set up in a Partial lattice design with three replications at Central Sericultural Germplasm Resources Center, (CSGRC), Hosur, Tamil Nadu, India. The centre is situated at 12.45° N, 77.51° E and 942 m altitude with tropical dry climate. The average rainfall ranges from 500 – 1000 mm per annum. The soil is red loamy with pH 6.5 – 7.5. The plantation was maintained as low bush with 90 x 90 cm spacing with 9 plants per replication with standard cultural practices (Thangavelu *et al.*, 2000; Tikader and Rao, 2002). The first pruning was done after one year of establishment of the plantation, with four harvests per year after pruning at 90 days interval.

Data Recording

After 90 days of pruning seven plants were randomly sampled from each replication for evaluating eight growth and yield traits. The traits were number of branches per plant (NB), length of the longest shoot (LLS), total shoot length (TSL), internodal distance (ID), leaf moisture content (MC), leaf moisture retention capacity (MRC), leaf yield per plant (LYD) and single leaf weight (SLW). The data on agronomical traits were collected 4 times per

TABLE 1
Details of indigenous mulberry accessions used for the study

Sl No.	Accession	Accession name	Collection/origin (State)
1	MI-0029	Kollegal	Karnataka
2	MI-0080	BC259	West Bengal
3	MI-0154	UP-14	Uttar Pradesh
4	MI-0252	Kalimpong local	West Bengal
5	MI-0290	*Morus alba*	Karnataka
6	MI-0296	Acc.16	Karnataka
7	MI-0301	Acc.1	Karnataka
8	MI-0308	V1	Karnataka
9	MI-0310	Chak Majra	Uttarakhand
10	MI-0312	Gulikadava	Kerala
11	MI-0313	Seekupari	Tamil Nadu
12	MI-0324	ERRC-101	Kerala
13	MI-0326	ERRC-71	Kerala
14	MI-0346	Tingari local	Assam
15	MI-0349	Garobodha	Meghalaya
16	MI-0369	Resham Majri - 6	Uttarakhand
17	MI-0370	Resham Majri - 7	Uttarakhand
18	MI-0376	Kunjagao - 2	Uttarakhand
19	MI-0388	Herbertpur	Uttarakhand
20	MI-0400	Krishnaswami - 2	Karnataka
21	MI-0415	Guhanathapuram	Kerala
22	MI-0416	Keeraithodu	Kerala
23	MI-0431	Saharanpur Road	Uttarakhand
24	MI-0437	Baragarh - 2	Uttarakhand
25	MI-0439	RSRS, Sahaspur	Uttarakhand

year for 3 years resulting in 13 harvests from 2002 – 2006. Standard procedures were followed as described by various authors (Jolly and Dandin, 1986; Machii *et al.*, 1997, 2001; Tikader and Rao, 2002; Thangavelu *et al.*, 2000). The leaf moisture content and leaf moisture retention capacity was calculated as described by Tikader and Roy (1999) and Vijayan *et al.* (1996, 1997).

$$\text{Moisture content (\%)} = \frac{\text{Leaf weigh fresh} - \text{Oven dry leaf weight}}{\text{Leaf weight fresh}} \times 100$$

$$\text{Moisture retention capacity (\%)} = \frac{\text{Leaf weighafter 6 hours dry} - \text{Oven dry leaf weight}}{\text{Leaf weightfresh} - \text{Oven dry leaf weight}} \times 100$$

Data Analysis

Data was y analysed using the SPSS statistical package. Analysis of variance of the eight growth and yield traits were carried out using with the adjusted values. The mean values for eight growth and yield traits were used for correlation matrix and cluster analysis. Pair wise distances between the accessions based on Mahalanobis distances were recorded (Mahalanobis, 1936). Ward's minimum variance cluster analysis was used to group the tested mulberry germplasm accessions (Ward, 1963). The selection index was based on the method described by The International Maize and Wheat Improvement Centre (CIMMYT).

RESULTS AND DISCUSSION

The mulberry germplasm accessions tested in this experiment are presented in Table 1. The accessions were collected from different sources through surveys and exploration and collections from institutes.

Variability Among Mulberry Accessions

The agronomic variation among the accessions is presented in Table 2. A high variation was observed in different growth and yield related traits. The ranges for the different traits are as follows: number of branches per plant (9.30 – 14.39); length of the longest shoot (122.43 – 176.38 cm); total shoot length (891.26 – 1718.38 cm); internodal distance (4.19 – 6.96 cm); leaf moisture content (70.22 – 75.79%); leaf moisture retention capacity (61.00 – 72.75%); leaf yield per plant (496.68 – 1071.08 g) and single leaf weight (1.82 – 6.80 g). The coefficient of variation was maximum in single leaf weight (36.32%) followed by leaf yield per plant (17.83%); total shoot length (16.48%); number of branches per plant (12.03%) and minimum for leaf moisture content (2.08%). The F-ratio indicated that all the accessions were highly significant for all the traits. The seasonal variation was also highly significant (1% probability) except for the number of branches per plant. The interaction between accession x season was also significant at 5% probability level. These results agree with the observations made by Tikader and Roy (2001) and Tikader and Dandin (2005).

Simple Correlation Matrix

Simple correlation coefficient was carried out among the accessions on different growth and yield traits (Table 3). The leaf yield was expressed in combination with other traits such as length of the longest shoot, total shoot length, leaf moisture content and leaf moisture retention capacity. Other traits showed a complex association with each other. Individual traits showed positive association such as number of branches per plant with total shoot length (0.90**) and negative association with leaf moisture retention capacity (-0.46*) and single leaf weight (-0.48*); length of the longest shoot was positively associated with total shoot length (0.69**) and leaf yield per plant (0.51**); total shoot length showed a positive association with leaf yield (0.52**); internodal distance was positively associated with leaf moisture content (0.55**), Leaf moisture retention capacity (0.59**) and single leaf weight (70**); leaf moisture content showed positive relationships with leaf moisture retention capacity (0.77**), leaf yield per plant (0.46*) and single leaf weight (0.76**); leaf moisture retention capacity showed positive relationships with leaf yield per plant (0.53**) and single leaf weight (0.91**). Similar observations on association of different traits with leaf yield was also reported by Sarkar *et al.*, (1987), Tikader and Roy (2001), Tikader and Dandin (2005) and Vijayan *et al.* (1997).

Divergence Analysis

The genetic diversity analysis among the mulberry accessions was carried out and the accessions were grouped into 7 clusters following divergence

TABLE 2
Mean performance of indigenous mulberry accessions

Sl. No.	Accessions	NB	LLS	TSL	INTD	MC	MRC	LYD	SLW
1	MI-0029	14.39	154.62	1718.60	5.08	73.53	63.50	818.42	2.22
2	MI-0080	9.35	122.43	891.26	5.15	75.28	71.12	686.10	5.77
3	MI-0154	11.92	166.81	1521.28	4.41	71.33	65.83	866.92	2.36
4	MI-0252	10.11	174.56	1257.08	6.96	74.47	72.20	828.87	6.80
5	MI-0290	12.61	170.88	1605.33	5.35	73.28	63.12	796.38	2.59
6	MI-0296	14.27	143.28	1611.64	5.19	71.81	61.83	790.23	2.55
7	MI-0301	10.08	142.69	1120.67	5.09	73.92	68.17	598.83	3.49
8	MI-0308	11.31	165.98	1434.08	5.18	74.96	72.36	906.57	4.44
9	MI-0310	11.21	150.40	1338.80	5.57	74.56	72.32	993.35	5.46
10	MI-0312	10.27	154.28	1225.83	4.44	70.74	61.49	496.68	1.88
11	MI-0313	13.67	161.67	1677.55	4.43	71.78	61.00	788.86	2.16
12	MI-0324	11.81	152.00	1365.14	5.96	73.57	70.21	820.70	4.80
13	MI-0326	11.65	153.07	1297.08	5.59	73.66	70.08	746.93	4.86
14	MI-0346	12.73	151.62	1515.06	4.19	70.22	63.45	725.63	1.82
15	MI-0349	11.93	147.00	1355.28	4.78	72.49	63.29	612.02	2.51
16	MI-0369	12.13	139.00	1347.68	5.14	74.19	69.91	861.65	3.80
17	MI-0370	9.30	135.10	970.08	4.30	72.07	65.12	526.07	2.54
18	MI-0376	13.10	176.38	1715.08	6.06	75.24	70.80	902.59	4.12
19	MI-0388	10.92	127.45	1085.68	4.98	73.29	67.46	657.16	3.73
20	MI-0400	10.88	133.34	1145.50	5.28	74.21	67.82	719.67	4.19
21	MI-0415	11.28	145.64	1294.93	5.52	70.75	67.60	709.45	3.42
22	MI-0416	11.60	174.45	1552.23	4.92	73.37	70.66	1071.08	5.18
23	MI-0431	10.86	150.07	1278.90	5.15	74.13	69.69	860.20	4.61
24	MI-0437	10.74	145.81	1244.30	5.03	75.79	72.75	950.21	5.59
25	MI-0439	9.95	160.01	1239.05	5.35	73.18	69.05	725.85	4.53
Mean		11.52	151.94	1352.32	5.16	73.27	67.63	778.42	3.82
Min		9.30	122.43	891.26	4.19	70.22	61.00	496.68	1.82
Max		14.39	176.38	1718.60	6.96	75.79	72.75	1071.08	6.80
SE		0.28	2.92	44.58	0.12	0.31	0.76	27.75	0.28
CV%		10.03	9.60	16.48	11.74	2.08	5.61	17.83	36.32
F-test									
Accession		**	**	**	**	**	**	**	**
Season		NS	**	**	**	**	**	**	**
Acc x sea		NS	**	**	**	**	**	**	**

**, Significant at 1% level, NS = Non-significant
NB = Number of branches per plant, LLS= Length of the longest shoot (cm), TSL = Total shoot length (cm), INTD=Internodal distance (cm), MC= Leaf moisture content (%), MRC=Leaf moisture retention capacity (%), LYD= Leaf yield per plant (g), SLW= Single leaf weight (g)

analysis (Table 4). Cluster I consisted of 6 accessions followed by 5 accessions each in clusters II and V and one accession each in cluster III and VI. The accessions grouped in cluster I showed the highest number of branches per plant (13.27) and total shoot length (1608.24 cm) (Table 5). Cluster II showed the highest leaf moisture content (74.78%) and leaf yield per plant (964.76g). Cluster III showed longer internodal distance, though a negative trait, it can be improved through suitable breeding approaches. The high single leaf weight was directly proportional to a longer internodal distance as reported by Tikader and Roy (2001). The other accessions that are grouped in clusters with traits having minimum values provide scope for further selection and improvement. All the materials collected from different geographical regions grouped in the same cluster or nearby cluster showed no relationship between genetic divergence and geographical diversity. Similar results were also highlighted by various authors

TABLE 3
Correlation matrix of different growth and yield traits in mulberry accessions

Traits	X1	X2	X3	X4	X5	X6	X7	X8
X1	——							
X2	0.33	——						
X3	0.90**	0.69**	——					
X4	-0.07	0.29	0.01	——				
X5	-0.23	-0.01	-0.19	0.55**	——			
X6	-0.46*	0.05	-0.33	0.59**	0.77**	——		
X7	0.35	0.51**	0.52**	0.33	0.46*	0.53**	——	
X8	-0.48*	0.04	-0.37	0.70**	0.76**	0.91**	0.48*	——

*, Significant at 5% level **, Significant at 1% level
X1 = Number of primary branches, X2 = Length of the longest shoot (cm),
X3 = Total shoot length (cm), X4 = Internodal distance (cm),
X5= Leaf moisture content (%), X6 = Leaf moisture retention capacity (%),
X7 = Leaf yield per plant (g), X8 = Single leaf weight (g)

TABLE 4
Distribution of indigenous mulberry accessions in different clusters

Clusters	No. of mulberry accessions	Accession details with States of India
I	6	MI-0029 - Kollegal (Karnataka)
		MI-0296 – Acc. 16 (Karnataka)
		MI-0290 - *Morus alba* (Karnataka)
		MI-0313 - Seekupari (Tamil Nadu)
		MI-0346 – Tingari local (Assam)
		MI-0154 – UP – 4 (Uttar Pradesh)
II	5	MI-0310 - Chak Majra (Uttarakhand)
		MI-0437- Baragarh –2 (Uttarakhand)
		MI-0308- V1 (Karnataka)
		MI-0416 – Keeraithodu (Kerala)
		MI-0376 – Kunjagao –2 (Uttarakhand)
III	1	MI-0252 – Kalimpong local (West Bengal)
IV	3	MI-0312- Gulikadava (Kerala)
		MI-0349- Garobodha (Meghalaya)
		MI-0370- Resham Majri – 7(Uttarakhand)
V	5	MI-0324- ERRC – 101 (Kerala)
		MI-0326- ERRC-73 (Kerala)
		MI-0439– RSRS, Sahaspur (Uttarakhand)
		MI-0369- Resham Majri –6 (Uttarakhand)
		MI-0431- Saharanpur Road (Uttarakhand)
VI	1	MI-0415- Guhanathapuram (Kerala)
VII	4	MI-0388 - Herbertpur (Uttarakhand)
		MI-0400- Krishnaswami –2 (Karnataka)
		MI-0301 - Acc. 1 (Karnataka)
		MI-0080 - BC259
Total	25	

TABLE 5
Cluster mean of growth traits of indigenous mulberry based on D2 values

Traits	Clusters						
	I	II	III	IV	V	VI	VII
X1	13.27	11.59	10.11	10.50	11.28	11.28	10.31
X2	158.15	162.60	174.56	145.46	150.83	145.64	131.48
X3	1608.24	1456.90	1257.08	1183.73	1305.57	1294.93	1060.78
X4	4.77	5.35	6.96	4.51	5.44	5.52	5.12
X5	71.99	74.78	74.47	71.76	73.75	70.75	74.17
X6	63.12	71.78	72.20	63.29	69.79	67.60	68.64
X7	797.75	964.76	828.87	544.92	803.07	709.45	665.44
X8	2.28	4.96	6.80	2.31	4.52	3.42	4.29

X1 = Number of branches per plant,
X2 = Length of the longest shoot (cm),
X3 = Total shoot length (cm),
X4 = Internodal distance (cm),
X5 = Leaf moisture content (%),
X6 = Leaf moisture retention capacity (%),
X7 = Leaf yield per plant (g),
X8 = Single leaf weight (g)

TABLE 6
Average inter and intra-cluster D2 values in 7 clusters

Clusters	I	II	III	IV	V	VI	VII
I	**2.37**	4.67	6.58	4.04	3.98	3.43	5.04
II		**2.64**	3.90	5.66	2.71	4.20	4.34
III			**0.00**	6.78	3.77	4.94	5.08
IV				**2.51**	4.12	3.04	3.64
V					**1.70**	2.57	2.77
VI						**0.00**	3.19
VII							**2.06**

Normal values indicate inter cluster distance
Bold values indicate intra-cluster distance

(Rajan *et al.*, 1997; Tikader and Roy, 2002; Tikader and Rao, 2003).

The average inter and intra-cluster distance presented in Table 6, reveals that a single accession in cluster III, has minimum intra-cluster distance. The maximum intra-cluster distance was in cluster II (2.64) and the accessions grouped in this cluster are diverse. The inter-cluster distance ranged from 2.71 to 6.78. The minimum inter-cluster distance was observed between cluster II and cluster V (2.71) which revealed close relationship among the accessions while the maximum inter-cluster distance was observed between clusters III and IV (6.78) thus revealing maximum diversity among the accessions.

CIMMYT Selection Index

The mulberry accessions are grouped based on the overall performance through CIMMYT selection index to select the high performing accessions for further use (Table 7). Mulberry accession MI-0416 performed better than all the other test materials while MI-0370 and MI-0312 were the poorest performers among the mulberry accessions tested. Due to the need for further utilization, other suitable mulberries may be selected from the pooled accessions.

TABLE 7
Listing of selected mulberry germplasm accessions (CIMMYT selection index)

Sl no.	Acc. no	Index	NB	LLS	TSL	INTD	MC	MRC	LYD	SLW
1	MI-0416	15	11.60	174.45	1552.23	4.92	73.37	70.66	1071.08	5.18
2	MI-0376	17	13.10	176.38	1715.08	6.06	75.24	70.80	902.59	4.12
3	MI-0308	17	11.31	165.99	1434.08	5.18	74.96	72.36	906.57	4.44
4	MI-0437	19	10.74	145.81	1244.30	5.03	75.79	72.75	950.21	5.59
5	MI-0310	19	11.21	150.40	1338.80	5.57	74.56	72.32	993.35	5.45
6	MI-0431	21	10.86	150.07	1278.90	5.15	74.13	69.69	860.20	4.61
7	MI-0369	21	12.13	139.00	1347.68	5.14	74.19	69.91	861.65	3.80
8	MI-0029	21	14.39	154.62	1718.60	5.08	73.53	63.50	818.42	2.22
9	MI-0326	22	11.65	153.07	1297.08	5.59	73.66	70.08	746.93	4.86
10	MI-0324	22	11.81	152.00	1365.14	5.96	73.57	70.21	820.70	4.80
11	MI-0290	22	12.61	170.88	1605.33	5.35	73.28	63.12	796.38	2.59
12	MI-0154	22	11.92	166.81	1521.28	4.41	71.33	65.83	866.92	2.36
13	MI-0313	23	13.67	161.67	1677.55	4.43	71.78	61.00	788.86	2.16
14	MI-0439	24	9.95	160.01	1239.05	5.35	73.18	69.05	725.85	4.53
15	MI-0252	24	10.11	174.56	1257.08	6.96	74.47	72.20	828.87	6.80
16	MI-0296	24	14.27	143.28	1611.64	5.19	71.81	61.83	790.23	2.55
17	MI-0400	25	10.88	133.34	1145.50	5.28	74.21	67.82	719.67	4.19
18	MI-0346	26	12.73	151.62	1515.06	4.19	70.22	63.45	725.63	1.82
19	MI-0349	26	11.93	147.00	1355.28	4.78	72.49	63.29	612.02	2.51
20	MI-0301	26	10.08	142.68	1120.67	5.09	73.92	68.17	598.83	3.49
21	MI-0415	27	11.28	145.64	1294.93	5.52	70.75	67.60	709.45	3.42
22	MI-0388	27	10.92	127.45	1085.68	4.98	73.29	67.46	657.16	3.77
23	MI-0080	28	9.35	122.43	891.26	5.15	75.28	71.12	686.10	5.77
24	MI-0312	31	10.27	154.28	1225.83	4.44	70.74	61.49	496.68	1.88
25	MI-0370	31	9.30	135.10	970.08	4.30	72.07	65.12	526.07	2.54

NB = Number of primary branches, LLS = Length of the longest shoot (cm),
TSL = Total shoot length (cm), ID = Internodal distance (cm),
MC= Leaf moisture content (%), MRC = Leaf moisture retention capacity (%),
LYD = Leaf yield per plant (g), SLW = Single leaf weight (g)

CONCLUSIONS

The mulberry accessions were selected from a field gene bank after preliminary characterization. The evaluation of mulberry accessions in this particular statistical design, interaction of accession and season have provided relevant data to estimate their ability to establish and express their potential. The analysis of variance, correlation, genetic diversity and selection indices have shown that the selected accessions have performed equally well with the existing high yielding genotypes. Some mulberry accessions performed better (MI-0416) and at par (MI-0376) with the check (MI-0308). These accessions with desirable traits may be selected and exploited for crop improvement in future mulberry breeding programmes.

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